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Suppliers' Information Note

For The Openreach Network

Optical Spectrum Extended Access 6500 (OSEA 6500) including Filter Connect

Service & Interface Description

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1. Introduction

This Suppliers Information Note (SIN) describes the Openreach Optical Spectrum Extended Access 6500 (OSEA 6500) service and its interfaces, including Filter Connect. OSEA 6500 and OSEA 6500 Filter Connect are Openreach Connectivity Services products within the Optical Spectrum Services portfolio.

This document should be read in conjunction with the OSEA Product Description available on the Openreach portal

https://www.openreach.co.uk/orpg/home/products/opticalservices/opticalservices.do

Note: Openreach has provided formal notification that the 2.7G MOTR wavelength card is not available for new supply after 22 January 2023.

2. General Service Outline

OSEA 6500 and OSEA 6500 Filter Connect is an end-to-end wavelength service between sites delivered over Openreach provided fibre infrastructure using DWDM (Dense Wavelength Division Multiplexing) technology. OSEA 6500 and OSEA 6500 Filter Connect is suitable for linking end user sites, or an end user site to a CP site. OSEA 6500 and OSEA 6500 Filter Connect is remotely monitored by Openreach.

OSEA 6500 Filter Connect variant allows customers to directly connect to the OSEA passive optical filters for the passing of their own traffic over the same fibre using dedicated wavelengths.

High bandwidth connectivity of up to 800Gbit/s per DWDM wavelength is offered. Managed wavelengths of 10Gbit/s and coherent from 100Gbit/s up to 800Gbit/s (with 100Gbit/s incrementals) or a combination of these can be supported on each OSEA 6500 or OSEA 6500 Filter Connect bearer. 40Gbit/s wavelengths are supported on existing OSEA 6500 and OSEA 6500 Filter Connect bearers but are no longer available for new orders. 40Gbit/s client interfaces are available over a 100Gbit/s wavelength.

The OSEA Link Bearer is a DWDM line system used to construct OSEA Ring and Chain topologies (such as ring, chain, hub and spoke or mesh). Specific technical details not covered in this document will be shared with the customer for each OSEA Ring and Chain design. OSEA Ring and Chain configurations do not support Filter Connect.

The elements of the service are:

Bearer: this is the DWDM line system which can support a mix of up to 44 wavelengths. The default OSEA 6500 bearer installation is configured to support up to four wavelengths (wavelengths are ordered separately). The default OSEA 6500 Filter Connect 'base build' bearer installation is configured to support up to eight wavelengths, with a single 10Gbit/s managed wavelength included. OSEA Link Bearer is a building block to provide OSEA Rings and Chains connectivity between multiple sites when matched to components like ROADM, amplifiers and wavelength transponders.**Expansion units:** these provide the capacity for additional wavelengths and end-point amplification on the OSEA Ring and Chain, OSEA 6500 or OSEA 6500 Filter Connect bearer. Any of the four NTE chassis types are available to use as expansion units depending on the amount of additional equipment required or the rack space available

Auxiliary units (Dispersion Compensation Modules – DCMs): these are used when needed on long lines to counteract the effects of Chromatic Dispersion on 10Gbit/s wavelengths.

End-point amplification: Dependant on the configuration of the service and the length of the fibre route, additional end-point amplification may be required to ensure the OSEA Ring and Chain, OSEA 6500 or OSEA 6500 Filter Connect bearer system works effectively.

Mid-point amplification: Mid-point amplification, also known as Intermediate Line Amplification (ILA) is typically required for fibre route distances in excess of 113km. This amplification is usually sited in a suitable BT Node or in customer owned and managed cabinets / racks at a site or Licenced area in a BT exchange. OSEA 6500 Filter Connect supports a maximum of one ILA.

Managed Wavelengths: these are ordered separately from the bearer and are specific to the protocol and speeds required. They are installed in the OSEA Ring and Chain, OSEA 6500 or OSEA 6500 Filter Connect bearer.

The OSEA Ring and Chain, OSEA 6500 and OSEA 6500 Filter Connect service has no maximum radial distance between BT serving exchanges. The maximum fibre route distance between OSEA Ring and Chain, OSEA 6500 and OSEA 6500 Filter Connect bearer circuit end points is also not limited; however additional amplification may be required as the fibre route distance increases.

3. NTE vendor

The Network Terminating Equipment (NTE) type used is the Ciena 6500.

4. Filter Connect

Filter Connect is an enhancement to the base Openreach OSEA 6500 product offering that enables Communications Providers (CPs) to access the optical bearer, via spare ports on the optical filter, with their own WDM wavelengths (also known as 'Alien' wavelengths. This will allow CPs to create and manage their own optical services whilst sharing the Openreach Optical infrastructure.

Openreach will maintain a minimum of one managed wavelength per OSEA 6500 Filter Connect bearer and then all other filter ports are available for the CP use as required. CPs can also choose to have multiple managed wavelengths from Openreach on the service. Openreach retain ownership of the OSEA equipment, filters and fibre.

Filter Connect is available for Point-to-Point and Core Network Access Link bearers only. OSEA Ring and Chain configurations do not support Filter Connect.

4.1 OSEA 6500 Filter Connect Structure

The OSEA 6500 Filter Connect service has a base-build consisting of three components; a 2 Slot 6500 2U bearer, an eight channel filter pair and a 10G Dual Port card pair. This offers 1x10Gbit/s wavelength day one with the second 10Gbit/s wavelength available as a chargeable upgrade. This will have a standard published price in the Openreach Price List.

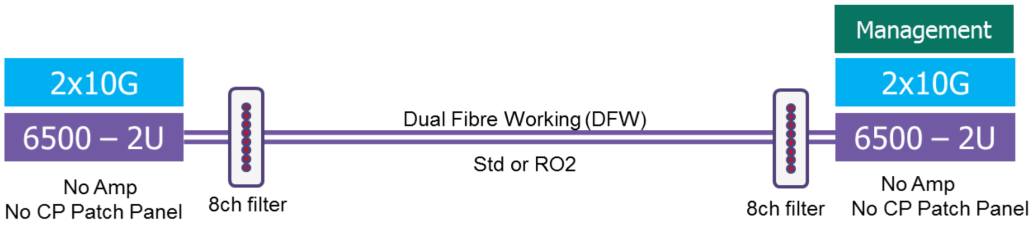

Figure 1 Base Build OSEA 6500 Filter Connect system

The base-build will have various options for customisation with prices as shown in the Openreach Price List:

Larger Bearer Chassis

- The CP can choose from all other Ciena 6500 Chassis options. (6U 6500-7 or 13U 6500-14 or 22U 6500-32)

Different filter configurations for future additional managed or CP's own wavelengths

- 4 channels using OMDF4 Filter

- 12 channels using both OMDF4 & OMDF8 Filters
- 42 channels using CMD42 Filter
- 44 channels using CMD44 or CMD96* Filters

*Note the CMD96 will give the CP access to up to 44 wavelengths across 88 channels of the C-Band. To be used only in Core Network Access Links. The CMD96 filter is not available for new supply.

4.2 Alternative wavelength cards / client interfaces

The full range of wavelength cards and client interfaces are available as per the existing OSEA 6500 product. These can be substituted for the 10G Dual Port card (10Gbit/s) on the base-build, or added as an additional managed wavelength.

4.3 Filter Port Allocation Guidance

Ciena will connect managed Openreach wavelengths from the lowest channel number on the filter working upwards towards the highest channel number. It is recommended that the CP connects their wavelengths from the highest channel number on the filter and works downwards towards the lowest channel number.

5. OSEA 6500 Filter Connect Network Parameters

This section provides guidance to CP's on using the spare filter ports on a Filter Connect build.

5.1 Frequency Plan

OSEA 6500 uses three types of filters: OMDF, and CMD and Advanced Amplifier and Filter Chassis. The filters of OSEA 6500 use 50GHz, 100GHz (Table 1) or 112.5GHz (Table 2) spacing for ITU-T grid compliant optics. Table 1 below shows the OMDF filter channels/port numbers and the filter plans to the left and the CMD filter channels / port numbers to the right. Table 3 below shows the Advanced Amplifier and Filter Chassis filter channels/ports numbers which are the same numbers as the OMDF. The CMD44 is a 100GHz filter and as such uses the same 100GHz frequencies/wavelengths as the OMDF variants. The CMD96 is a 50GHz filter and provides access to up to 44 of the 88 frequencies/wavelengths as shown in Table 1 below. The CMD96 filter is not available for new supply. The CMD42 filter introduce 112.5Ghz spacing in OSEA6500 for wider ITU-T grid compliant optics / wavelength, shown in Table 2 below.

OMDF CHANNEL #	OMDF4	OMDF8	WAVELENGTH (nm)	FREQUENCY (THz)	CMD44 CHANNEL #	CMD96 CHANNEL #
59	A4H	A-80	1530.33	195.9	1	1
			1530.72	195.85		2
58			1531.12	195.8	3	3
			1531.51	195.75		4
57			1531.9	195.7	5	5
			1532.29	195.65		6
56			1532.68	195.6	7	7
			1533.07	195.55		8
55	A4L		1533.47	195.5	9	9
			1533.86	195.45		10
54			1534.25	195.4	11	11
			1534.64	195.35		12
53			1535.04	195.3	13	13
			1535.43	195.25		14
52			1535.82	195.2	15	15

OMDF CHANNEL #	OMDF4	OMDF8	WAVELENGTH (nm)	FREQUENCY (THz)	CMD44 CHANNEL #	CMD96 CHANNEL #
			1536.22	195.15		16
51			1536.61	195.1	17	17
			1537	195.05		18
50	B4H	B-80	1537.4	195	19	19
			1537.79	194.95		20
49			1538.19	194.9	21	21
			1538.58	194.85		22
48			1538.98	194.8	23	23
			1539.37	194.75		24
47			1539.77	194.7	25	25
			1540.16	194.65		26
46	B4L		1540.56	194.6	27	27
			1540.95	194.55		28
45			1541.35	194.5	29	29
			1541.75	194.45		30
44			1542.14	194.4	31	31
			1542.54	194.35		32
43			1542.94	194.3	33	33
			1543.33	194.25		34
42			1543.73	194.2	35	35
			1544.13	194.15		36
41	C4H	C-80	1544.53	194.1	37	37
			1544.92	194.05		38
40			1545.32	194	39	39
			1545.72	193.95		40
39			1546.12	193.9	41	41
			1546.52	193.85		42
38			1546.92	193.8	43	43
			1547.32	193.75		44
37	C4L		1547.72	193.7	45	45
			1548.11	193.65		46
36			1548.51	193.6	47	47
			1548.91	193.55		48
35			1549.32	193.5	49	49
			1549.72	193.45		50
34			1550.12	193.4	51	51
			1550.52	193.35		52
33			1550.92	193.3	53	53
			1551.32	193.25		54

OMDF CHANNEL #	OMDF4	OMDF8	WAVELENGTH (nm)	FREQUENCY (THz)	CMD44 CHANNEL #	CMD96 CHANNEL #
32	D4H	D-80	1551.72	193.2	55	55
			1552.12	193.15		56
31			1552.52	193.1	57	57
			1552.93	193.05		58
30			1553.33	193	59	59
			1553.73	192.95		60
29			1554.13	192.9	61	61
			1554.54	192.85		62
28	D4L		1554.94	192.8	63	63
			1555.34	192.75		64
27			1555.75	192.7	65	65
			1556.15	192.65		66
26			1556.55	192.6	67	67
			1556.96	192.55		68
25			1557.36	192.5	69	69
			1557.77	192.45		70
24			1558.17	192.4	71	71
			1558.58	192.35		72
23	E4H	E-80	1558.98	192.3	73	73
			1559.39	192.25		74
22			1559.79	192.2	75	75
			1560.2	192.15		76
21			1560.61	192.1	77	77
			1561.01	192.05		78
20			1561.42	192	79	79
			1561.83	191.95		80
19	E4L		1562.23	191.9	81	81
			1562.64	191.85		82
18			1563.05	191.8	83	83
			1563.45	191.75		84
17			1563.86	191.7	85	85
			1564.27	191.65		86
16			1564.68	191.6	87	87
			1565.09	191.55		88

Table 1: ITU Wavelength Grid for 100GHz spacing with OSEA6500 Filters

The CMD42 is a 112.5GHz filter and provides access to up to 42 frequencies / wavelengths as shown in table 2 below:

CMD42 CHANNEL #	WAVELENGTH (nm)	FREQUENCY (THz)

CMD42 CHANNEL #	WAVELENGTH (nm)	FREQUENCY (THz)

1	1529.31	196.03
2	1530.19	195.92
3	1531.07	195.81
4	1531.95	195.69
5	1532.83	195.58
6	1533.71	195.47
7	1534.59	195.36
8	1535.48	195.24
9	1536.36	195.13
10	1537.25	195.02
11	1538.14	194.91
12	1539.03	194.79
13	1539.91	194.68
14	1540.8	194.57
15	1541.7	194.46
16	1542.59	194.34
17	1543.48	194.23
18	1544.38	194.12
19	1545.27	194.01
20	1546.17	193.89
21	1547.07	193.78
22	1547.97	193.67
23	1548.86	193.56
24	1549.77	193.44
25	1550.67	193.33
26	1551.57	193.22
27	1552.47	193.11
28	1553.38	192.99
29	1554.29	192.88
30	1555.19	192.77
31	1556.1	192.66
32	1557.01	192.54
33	1557.92	192.43
34	1558.83	192.32
35	1559.74	192.21
36	1560.66	192.09
37	1561.57	191.98
38	1562.49	191.87
39	1563.4	191.76
40	1564.32	191.64
41	1565.24	191.53
42	1566.16	191.42

Table 2: ITU Wavelength Grid for 112.5GHz spacing with OSEA6500 Filters

ELS CHANNEL #	ELS Group - Large 48CH	ELS Group - Small 10CH	ELS Group - Small 6CH	WAVELENGTH (nm)	FREQUENCY (THz)
61	ELS 48CH	ALL	ALL	1528.77	196.1
60				1529.55	196
59		A8	A4H	1530.33	195.9
58				1531.12	195.8
57				1531.9	195.7
56				1532.68	195.6
55			A4L	1533.47	195.5
54				1534.25	195.4
53				1535.04	195.3
52				1535.82	195.2
51				1536.61	195.1
50		B8	B4H	1537.4	195
49				1538.19	194.9
48				1538.98	194.8
47				1539.77	194.7
46			B4L	1540.56	194.6
45				1541.35	194.5

ELS CHANNEL #	ELS Group - Large 48CH	ELS Group - Small 10CH	ELS Group - Small 6CH	WAVELENGTH (nm)	FREQUENCY (THz)
44				1542.14	194.4
43				1542.94	194.3
42				1543.73	194.2
41		C8	C4H	1544.53	194.1
40				1545.32	194
39				1546.12	193.9
38				1546.92	193.8
37			C4L	1547.72	193.7
36				1548.51	193.6
35				1549.32	193.5
34				1550.12	193.4
33				1550.92	193.3
32		D8	D4H	1551.72	193.2
31				1552.52	193.1
30				1553.33	193
29				1554.13	192.9
28			D4L	1554.94	192.8
27				1555.75	192.7
26				1556.55	192.6
25				1557.36	192.5
24				1558.17	192.4
23		E8	E4H	1558.98	192.3
22				1559.79	192.2
21				1560.61	192.1
20				1561.42	192
19			E4L	1562.23	191.9
18				1563.05	191.8
17				1563.86	191.7
16				1564.68	191.6
15				1565.5	191.5
14		ALL	ALL	1566.31	191.4

Table 3: ITU Wavelength Grid for 100GHz spacing with Advanced Amplifier and Filter Chassis on OSEA6500

*Advanced Amplifier and Filter Chassis also referred to as ELS

5.2 Channel Isolation

The channel isolation specification for all filter types is given below:

Adjacent Channel Isolation (dB)	23
Non-Adjacent DWDM Channel Isolation (dB)	30

Table 4: OSEA 6500 Filter Isolation

5.3 Optical Safety Limits

The maximum CP Tx output power launched into the optical filter shall be no more than **+6dBm** for any filter configuration. This is to ensure that the solution remains compliant with class 1M from IEC 60825-2 (Safety of Optical Fibre Communications Systems) after the WDM signals are combined by the optical filter. It is the CPs responsibility to ensure that light levels for each optical channel do not exceed this figure.

5.4 10G non-coherent WDM Specifications

10G non-coherent WDM of the following specifications have been used to calculate the maximum optical reach.

- **ITU-T G.698:** These specifications are easy to achieve. For example, they are realisable with most tuneable plugs for 10GE framed WDM.

- **High Performance without FEC:** This is a specification for a higher quality interface without FEC.

- **High Performance with FEC:** Optical reaches of this type are typically delivered using Forward Error Correction and by careful qualification of the same 10G non-coherent WDM at both ends of the link to reduce variety.

If the CP's 10G non-coherent WDM performance meets or exceeds:

- ITU-T G.698: the CP can order the ITU-T G.698 reaches in Table 5

- High Performance without FEC: the CP can order the "No FEC" reaches in Table 5

- The High Performance with FEC reaches in Table 5 give some guidance on what can be achieved and are the maximum reaches Ciena will support for the relevant designs.

10G non-coherent WDM with inferior specifications to the ITU-T G.698 ones listed below are not supported on OSEA 6500 Filter Connect.

Parameters	**G.698.1-A** *ITU-T G.698.1 (11/2009)*	**G.698.2-B** *ITU-T G.698.2 (11/2009)*	**G.698.2-C** *ITU-T G.698.2 (11/2009)*	**High Perf. Loss Limited**	**High Perf. OSNR Limited**
Photonic configurations	No amps	Pre-amp or Post-&Pre-amp	Post and pre-amp	No amps	Pre-amp or Post-&Pre-amp
Baseline G.698 WDM TxRx code	DN100S-2D2(C)	DN50C-2A2(C)	DN100C-2A2(C)	-	-
Modifications from baseline G.698 standard	None	Dispersion tolerance increased Tx power variation reduced. [Note 1]	None	-	-
Approx. data rate (Gbps)	10	10	10	10	10
FEC	No	No	No	No	No
Max mean channel output power from Tx (dBm)	3	3	6	3	3
Min mean channel output power from Tx (dBm)	-1	-1	-3	-1	-1
Max (residual) chromatic dispersion (ps/km)	1100	1400	800	1500	1500
Max optical path penalty (dB)	2.5	5	5	2.1	-
Min Rx sensitivity at 0km transmission (dBm)	-22	-	-	-22.5	-
Min Rx sensitivity at maximum reach quoted (dBm)	-19.5	-	-	-20.4	-
Max mean Rx input power (dBm)	-	-8	-8 (0) [Note 2]	-7	-7
Min mean Rx input power (dBm)	-	-17	-17 (-11) [Note 2]	-	-20
Receiver OSNR tolerance at 0km transmission (dB [0.1nm])	-	22	22	-	-
Min OSNR at max reach quoted (dB [0.1nm])	-	27	27	-	25.5
See the referenced standard for definitions of the above terms or other details of the specification.					
Note 1. These changes to the baseline reflect what can be achieved with typical tuneable plugs					
Note 2. The specifications in brackets () can be offered on request to accommodate PIN receivers					

Table 5: 10G non-coherent WDM Specifications

5.5 Adjustment for Optical Path Penalty for 10G non-coherent WDM

Note that:

- *min. Rx sens. at max. reach = min. Rx sens. at 0km - max. optical path penalty*
- *min. OSNR at max. reach = min. OSNR at 0km + max. optical path penalty*

Some systems vendors quote these specifications at 0km and some quote them at the maximum reach, so some care is required in comparing WDM and determining whether a path penalty needs to be added. An example of a minimum ONSR quoted at maximum reach is shown below.

> *Minimum Rx OSNR for BER <=1.0 x10-12, -300 to 1500 ps/nm dispersion, Rx input power in the range of -20 to -7 dBm, bit rate in the range of 9.95 to 10.709 Gb/s) = 25.5dB.*

5.6 Maximum Reach for Point-to-Point applications

The fibre type used to deliver the reaches below is G.652, with maximum fibre loss assumed to be **0.35dB/km**. This includes the loss of any patch panels and fusion splices used by Openreach, fibre ageing and repair margin. The worst case chromatic dispersion for OSEA configurations is **18.3 ps/nm/km**.

Table 6 specifies the maximum reach for 10G non-coherent WDM only. Table 7 specifies the maximum reach for 100G coherent WDM only. (Mixed 10G non-coherent and 100G coherent WDM is a supported configuration but it is not covered by the table immediately below). Table 8 specifies the maximum reach for tuneable coherent WDM wavelengths for 100G to 200G at 35GBd and 300G to 400G at 56GBd. Table 9 specifies the maximum reach for tuneable coherent WDM wavelengths for 100G to 800G. Tuneable coherent WDM wavelengths can only be mixed with coherent wavelegnths.

Configuration					Filter Type / Reach (km)				
Photonics	**TxRx**	**FEC**	**1x In Line Amp (2)**	**Min Chan.**	**No filter**	**4ch**	**8ch**	**12ch**	**44ch**
Non-amplified	G.698.1-A	no	-	1	-	40	37	23	20
	High perf. (1)				55	42	39	25	22
		yes			76	63	60	46	44
Pre-amplified	G.698.2-B	no	-	1	-	62	59	53	54
	High perf. (1)				-	65	61	55	57
		yes			-	78	76	69	70
				2	-	84	80	75	76
Pre-amplified wDCMs	High perf. (1)	no	Pre-amp	1	-	109	100	92	92
		yes			-	134	131	124	124
				2	-	140	136	125	124
Pre&Post-amp wDCMs	G.698.2-C	no	-	1	-	80	80	80	76
	High perf. (1)				-	95	95	93	84
		yes			-	120	120	120	110
		no	Pre&Post-amp		-	173	174	168	148
		yes			-	224	223	220	200

Table 6: Reach table for 10G non-coherent WDM

Configuration			Filter Type / Reach (km)				
Photonics	**1x In Line Amp (2)**	**Min Chan.**	**No filter**	**4ch**	**8ch**	**12ch**	**44ch**
Non-amplified	-	1	54	41	38	24	21

Pre-amplified	-	1	77	67	64	58	58
		2	-	74	69	63	65
	Pre-amp	1	-	122	118	106	106
		2	-	124	118	109	110
Pre&Post-amp	-	1	-	120	120	120	106
	Pre&Post-amp		-	220	219	215	190

Table 7: Reach table for 100G Coherent WDM

Line rate	GBaud	Configuration		Filter Type / Reach (km)			
		Photonics	1x In Line Amp (2)	No filter	4ch	8ch	44ch
100G-200G	35GBd	Non-amplified	-	88	75	71	55
300G	56GBd			84	71	68	52
400G	56GBd			70	57	54	37
100G-200G	35GBd	Pre-amplified	-	-	93	91	81
300G	56GBd			-	94	91	84
400G	56GBd			-	79	75	69
200G	35GBd		Pre-amp	-	149	146	131
300G	56GBd			-	147	142	127
400G	56GBd			-	127	122	112
100G-200G	35GBd	Pre&Post-amp	-	-	120	120	104
300G	56GBd			-	120	119	101
400G	56GBd			-	102	101	84
100G-200G	35GBd		Pre&Post-amp	-	215	212	186
300G	56GBd			-	216	213	179
400G	56GBd			-	173	169	144

Table 8: Reach table for Tuneable 100G-400G Coherent WDM at 35GBd and 56GBd

Photonics	1x In Line Amp (2)	Line Rate (@ 95GBd) / Reach (km)				
		200G-400G	500G	600G	700G	800G
-	-	45	45	39	31	21
Pre&Post-amp	-	107	100	92	83	69
	Pre&Post-amp	195	182	166	145	105

Table 9: Reach table for Tuneable 200G-800G Coherent WDM at 95GBd

(1) High performance optics; (2) Amplification per direction

The CP is responsible for ensuring that Transmit (Tx) and Receive (Rx) are compatible and are able to meet the specifications quoted on the request form. The CP is also responsible for alien WDM compatibility to achieve the WDM specifications summarized in the reach tables above. This is especially important in the transverse compatibility interoperation case where the WDM combination is less likely to have been tested by systems vendors.

5.7 Commissioning Alien Waves on Filter Connect

Equalisation is required when additional wavelengths are added to amplified Filter Connect systems. This involves inserting the appropriate sizes of pad between:

- Filter Connect and the Tx
- Filter Connect and the Rx.

CPs can perform their own equalization but note that a device capable of measuring per channel powers at 100GHz spacing is required or 112.5GHz if the design has used a CMD42. Options include an OSA (Optical Spectrum Analyzer) or Optical Channel Analyser, which is a smaller device measuring per wavelength power but not OSNR.

Equalization is not required for unamplified Filter Connect systems.

The following optical measurements will be shared via the customer handover pack following the certification of an OSEA 6500 Filter Connect bearer to enable customer network planning over the OSEA 6500 infrastructure.

- Per site / bearer details to be provided to CP via Customer Handbook:
- Per channel, end-to-end loss for non-amplified bearers
- Per channel, effective gain / loss on amplified bearers
- Total fibre route distance for ITU-T G.652 and details of value of dispersion compensation on link to determine, end to end Chromatic Dispersion.

5.8 OSEA 6500 and OSEA 6500 Filter Connect Customer Interface Information

Client services to card types, transparency and client port error signal

[1.] The 2.7G MOTR wavelength card is not available for new supply after 22 January 2023

Client Service	Card Type	Transparency	Client Port Options Pluggable type / maximum speed / wavelength /Single-Mode(SM) or Multimode (MM) / connector type	Client Port Signal Output on LOS (1)
G.709 OTU4 (111.809Gbit/s)	WL5E MOTR	ODU4 transparent, timing transparent	QSFP28/100G/1310/SM/LC	ODU4 AIS
	WLAi MOTR	ODU4 transparent, timing transparent	QSFP28/100G/1310/SM/LC	ODU4 AIS
	WL3n OTR	ODU4 transparent, timing transparent	QSFP28/100G/1310L/SM/LC	ODU4 AIS
G.709 OTU3 (43.018Gbit/s)	WL3 OCLD / 2x40G+2x10G OCI	ODU3 transparent, timing transparent	QSFP+/40G/1310L/SM/LC	ODU3 AIS
G.709 OTU2e (11.095Gbit/s)	WLAi FOTR	ODU2e transparent	SFP+/10G/1310nm/LC	ODU2e AIS
	WL3n MOTR	ODU2e transparent, timing transparent	SFP+/10G/1310/SM/LC	ODU2e AIS
	4x10G OTR XFP	ODU2e transparent, timing transparent	XFP/10G/1310S/SM/LC	ODU2e AIS
	2x10G OTR	ODU2e transparent, timing transparent	XFP/10G/1310S/SM/LC	ODU2e AIS
G.709 OTU2 (10.709Gbit/s)	WLAi FOTR	ODU2 transparent	SFP+/10G/1310/SM/LC	ODU2 AIS
	WL3n MOTR	ODU2 transparent, timing transparent	SFP+/10G/1310/SM/LC	ODU2 AIS
	4x10G OTR XFP	ODU2 transparent, timing transparent	XFP/10G/1310S/SM/LC	ODU2 AIS

Client Service	Card Type	Transparency	Client Port Options Pluggable type / maximum speed / wavelength /Single-Mode(SM) or Multimode (MM) / connector type	Client Port Signal Output on LOS (1)
	2x10G OTR	ODU2 transparent, timing transparent	XFP/10G/1310S/SM/LC	ODU2 AIS
400 Gigabit Ethernet (412.5 Gbit/s)	WL5E MOTR	Data and timing transparent	QSFP-DD/400G/1310/FR4/LC	Local Fault (LF)
		Data and timing transparent	QSFP-DD/400G/1310/DR4/MPO	Local Fault (LF)
100 Gigabit Ethernet (103.125GBit/s)	WL5E MOTR	Data and timing transparent	QSFP28/100G/1310/SM/LC	Local Fault (LF)
		Data and timing transparent	QSFP28/100G/850/MM/MPO	Local Fault (LF)
	WLAi MOTR	Data and timing transparent	QSFP28/100G/1310/SM/LC	Local Fault (LF)
		Data and timing transparent	QSFP28/100G/850/MM/MPO	
	WLAi FOTR	Data and timing transparent	QSFP28/100G/1310/SM/LC	Local Fault (LF)
		Data and timing transparent	QSFP28/100G/850/MM/MPO	
	WL3n OTR	Data and timing transparent	QSFP28/100G/1310L/SM/LC	Local Fault (LF)
		Data and timing transparent	QSFP28/100G/850S/MM/MPO	
40 Gigabit Ethernet (41.25GBit/s)	WL3 OCLD / 2x40G+2x10G OCI	Data and timing transparent	QSFP+/40G/1310L/SM/LC	Local Fault (LF)
		Data and timing transparent	QSFP+/40G/1310S/MM/MPO	
10Gbit/s Ethernet LAN PHY (10.3125 Gbit/s)	WLAi FOTR	Data and timing transparent	SFP+/10G/1310/SM/LC	Local Fault (LF)
		Data and timing transparent	SFP+/10G/850/MM/LC	

Client Service	Card Type	Transparency	Client Port Options Pluggable type / maximum speed / wavelength /Single-Mode(SM) or Multimode (MM) / connector type	Client Port Signal Output on LOS (1)
	WL3 OCLD / 2x40G+2x10G OCI	Data and timing transparent when mapped to OPU2e in ODU2e with BMP, PT=0x03	SFP+/10G/1310L/SM/LC	Local Fault (LF)
		Data and timing transparent when mapped to OPU2e in ODU2e with BMP, PT=0x03	SFP+/10G/850I/MM/LC	
	WL3n MOTR	Data and timing transparent when mapped to OPU2e in ODU2e with BMP, PT=0x04	SFP+/10G/1310L/SM/LC	Local Fault (LF)
		Data and timing transparent when mapped to OPU2e in ODU2e with BMP, PT=0x03	SFP+/10G/850S/MM/LC	
	4x10G OTR XFP	Data and timing transparent when mapped to OPU2e in ODU2e with BMP, PT=0x05	XFP/10G/1310S/SM/LC	Local Fault (LF)
		Data and timing transparent when mapped to OPU2e in ODU2e with BMP, PT=0x05	XFP/10G/850S/MM/LC	
	2x10G OTR	Data and timing transparent when mapped to OPU2e in ODU2e with BMP, PT=0x06	XFP/10G/1310S/SM/LC	Local Fault (LF)

Client Service	Card Type	Transparency	Client Port Options Pluggable type / maximum speed / wavelength /Single-Mode(SM) or Multimode (MM) / connector type	Client Port Signal Output on LOS (1)
		Data and timing transparent when mapped to OPU2e in ODU2e with BMP, PT=0x06	XFP/10G/850S/MM/LC	
10Gbit/s Ethernet WAN PHY (9.9532 Gbit/s)	WL3n MOTR	Data and timing transparent	SFP+/10G/1310L/SM/LC	Local Fault (LF)
	4x10G OTR SFP/SFP+	Data and timing transparent	SFP+/10G/1310L/SM/LC	Local Fault (LF)
	2x10G OTR	Data and timing transparent	XFP/10G/1310S/SM/LC	Local Fault (LF)
Gigabit Ethernet (1.25GBit/s)	2.7G MOTR [1]	Data and timing transparent	SFP/2.7G/1310I/SM/LC	Can be set to either 8B10B or K30_7
		Data and timing transparent	SFP/1.25G/850S/MM/LC	
	10G MOTR	Data and timing transparent	SFP/2.7G/1310I/SM/LC	Can be set to either 8B10B or K30_7
		Data and timing transparent	SFP/1.25G/850S/MM/LC	
Fibre Channel FC32G (28.05G)	WLAi FOTR	Data and timing transparent	SFP28/32GFC/1310/SM/LC	Local Fault (LF)
		Data and timing transparent	SFP28/32GFC/850/MM/LC	
Fibre Channel/FICON FC16G (14.025G)	WLAi FOTR	Data and timing transparent	SFP28/16GFC/1310/SM/LC	Local Fault (LF)
		Data and timing transparent	SFP28/16GFC/850/MM/LC	
Fibre Channel 10Gbit/s	WL3n MOTR	Data and timing transparent	SFP+/10G/1310L/SM/LC	Local Fault (LF)

Client Service	**Card Type**	**Transparency**	**Client Port Options** Pluggable type / maximum speed / wavelength /Single-Mode(SM) or Multimode (MM) / connector type	**Client Port Signal Output on LOS (1)**
FC1200 (10.5187Gbit/s)		Data and timing transparent	SFP+/10G/850I/MM/LC	
	4x10G OTR XFP	Data and timing transparent	XFP/10G/1310S/SM/LC	Local Fault (LF)
		Data and timing transparent	XFP/10G/850S/MM/LC	
	2x10G OTR	MAC transparent	XFP/10G/1310S/SM/LC	Local Fault (LF)
		MAC transparent	XFP/10G/850S/MM/LC	
Fibre Channel 8Gbit/s FC800 (8.5Gbit/s)	4x10G OTR SFP/SFP+	Data and timing transparent	SFP+/10G/1310L/SM/LC	NOS
		Data and timing transparent	SFP+/10G/850I/MM/LC	
	2x10G OTR	Data and timing transparent	XFP/10G/1310S/SM/LC	NOS
		Data and timing transparent	XFP/10G/850S/MM/LC	
Fibre Channel/FICON 4Gbit/s FC400 (4.25Gbit/s)	4x10G OTR SFP/SFP+	Data and timing transparent	SFP+/10G/1310L/SM/LC	NOS
		Data and timing transparent	SFP+/10G/850I/MM/LC	
	10G MOTR	Data and timing transparent	SFP/2.7G/1310L/SM/LC	Can be set to either 8B10B or NOS
		Data and timing transparent	SFP/2.7G/850I/MM/LC	
Fibre Channel/FICON	10G MOTR	Data and timing transparent	SFP/2.7G/1310I/SM/LC	Can be set to either 8B10B or

Client Service	**Card Type**	**Transparency**	**Client Port Options** Pluggable type / maximum speed / wavelength /Single-Mode(SM) or Multimode (MM) / connector type	**Client Port Signal Output on LOS (1)**
2Gbit/s FC200 (2.125 Gbit/s)		Data and timing transparent	SFP/1.25G/850S/MM/LC	NOS
	2.7G MOTR [1]	Data and timing transparent	SFP/2.7G/1310I/SM/LC	Can be set to either 8B10B or NOS
		Data and timing transparent	SFP/1.25G/850S/MM/LC	
Fibre Channel/FICON 1Gbit/s FC100 (1.062 Gbit/s)	10G MOTR	Data and timing transparent	SFP/2.7G/1310I/SM/LC	Can be set to either 8B10B or NOS
		Data and timing transparent	SFP/1.25G/850S/MM/LC	
	2.7G MOTR [1]	Data and timing transparent	SFP/2.7G/1310I/SM/LC	Can be set to either 8B10B or NOS
		Data and timing transparent	SFP/1.25G/850S/MM/LC	
STM-64 (9.9532 Gbit/s)	WL3n MOTR	Data and timing transparent	SFP+/10G/1310I/SM/LC	MS-AIS
	4x10G OTR XFP	Data and timing transparent	XFP/10G/1310S/SM/LC	MS-AIS
	2x10G OTR	Data and timing transparent	XFP/10G/1310S/SM/LC	MS-AIS
STM-16 (2.488 Gbit/s)	10G MOTR	Data and timing transparent	SFP/2.7G/1310I/SM/LC	MS-AIS
	2.7G MOTR [1]	Data and timing transparent	SFP/2.7G/1310I/SM/LC	MS-AIS
STM-4 (622 Mbit/s)	10G MOTR	Data and timing transparent	SFP/2.7G/1310I/SM/LC	MS-AIS
	2.7G MOTR [1]	Data and timing transparent	SFP/2.7G/1310I/SM/LC	MS-AIS

Client Service	Card Type	Transparency	Client Port Options Pluggable type / maximum speed / wavelength /Single-Mode(SM) or Multimode (MM) / connector type	Client Port Signal Output on LOS (1)
STM-1 (155 Mbit/s)	10G MOTR	Data and timing transparent	SFP/2.7G/1310I/SM/LC	MS-AIS
	2.7G MOTR [1]	Data and timing transparent	SFP/2.7G/1310I/SM/LC	MS-AIS
IBM PSIFB (5Gbit/s)	4x10G OTR SFP/SFP+	Data and timing transparent	SFP+/10G/1310L/SM/LC	Client shutoff
	2x10G OTR	Data and timing transparent	XFP/10G/1310S/SM/LC	Client shutoff
IBM ISC-3 Peer Mode 2G (2.125GBit/s)	4x10G OTR SFP/SFP+	Data and timing transparent	SFP+/10G/1310L/SM/LC	Client shutoff
	10G MOTR	Data and timing transparent	SFP/2.7G/1310I/SM/LC	8B10B
	2.7G MOTR [1]	Data and timing transparent	SFP/2.7G/1310I/SM/LC	8B10B
IBM ISC-3 Peer Mode 1G (1.0625Gbit/s)	10G MOTR	Data and timing transparent	SFP/2.7G/1310I/SM/LC	8B10B
	2.7G MOTR [1]	Data and timing transparent	SFP/2.7G/1310I/SM/LC	8B10B
DVB-ASI (270Mbit/s)	10G MOTR	Data and timing transparent	SFP/2.7G/1310I/SM/LC	8B10B
	2.7G MOTR [1]	Data and timing transparent	SFP/2.7G/1310I/SM/LC	8B10B

Table 10: Client Services Mappings to card types

5.9 Client optical power margins for both receive and transmit interfaces

Client Service	**Card Type**	**Client Port Options** Pluggable type / maximum speed / wavelength /Single-Mode(SM) or Multimode (MM) / connector type	**Rx Min** (dBm)	**Rx Max** (dBm)	**Tx Min** (dBm)	**Tx Max** (dBm)
G.709 OTU4 (111.809Gbit/s)	WL5E MOTR	QSFP28/100G/1310/SM/LC	-10.3	4.0	-3.6	6.0
	WLAi MOTR	QSFP28/100G/1310/SM/LC	-10.3	4.0	-3.6	6.0
	WL3n OTR	QSFP28/100G/1310L/SM/LC	-10.3	4.0	-3.6	6.0
G.709 OTU3 (43.018Gbit/s)	WL3 OCLD / 2x40G+2x10G OCI	QSFP+/40G/1310L/SM/LC	-12.8	2.3	-4.3	4.3
G.709 OTU2e (11.095Gbit/s)	WLAi FOTR	SFP+/10G/1310nm/LC	-13.0	0.5	-8.0	1.0
	WL3n MOTR	SFP+/10G/1310/SM/LC	-13.0	-1.0	-8.0	1.0
	4x10G OTR XFP	XFP/10G/1310S/SM/LC	-13.0	0.5	-8.0	1.0
	2x10G OTR	XFP/10G/1310S/SM/LC	-13.0	0.5	-8.0	1.0
G.709 OTU2 (10.709Gbit/s)	WLAi FOTR	SFP+/10G/1310/SM/LC	-13.0	0.5	-8.0	1.0
	WL3n MOTR	SFP+/10G/1310/SM/LC	-13.0	-1.0	-8.0	1.0
	4x10G OTR XFP	XFP/10G/1310S/SM/LC	-13.0	0.5	-8.0	1.0
	2x10G OTR	XFP/10G/1310S/SM/LC	-13.0	0.5	-8.0	1.0
400 Gigabit Ethernet (412.5 GBit/s)	WL5E MOTR	QSFP-DD/400G/1310/FR4/SM/LC	-7.3	3.5	-3.3	3.5
		QSFP-DD/400G/1310/DR4/SM/MPO	-7.1	4.5	-5.1	6
100 Gigabit Ethernet (103.125GBit/s)	WL5E MOTR	QSFP28/100G/1310/SM/LC	-10.6	4.5	-6.3	6.5
		QSFP28/100G/850/MM/MPO	-10.3	2.4	-11.4	5.4
	WLAi MOTR	QSFP28/100G/1310/SM/LC	-10.6	4.5	-6.3	6.5
		QSFP28/100G/850/MM/-MPO	-10.3	2.4	-11.4	5.4
	WLAi FOTR	QSFP28/100G/1310/SM/LC	-10.6	4.5	-6.3	6.5
		QSFP28/100G/850/MM/ MPO	-10.3	2.4	-11.4	5.4
	WL3n OTR	QSFP28/100G/1310L/SM/LC	-10.6	4.5	-6.3	6.5
		QSFP28/100G/850S/MM/MPO	-10.3	2.4	-11.4	5.4
40 Gigabit Ethernet (41.25GBit/s)	WL3 OCLD / 2x40G+2x10G OCI	QSFP+/40G/1310L/SM/LC	-13.7	2.3	-9	4.3
		QSFP+/40G/1310S/MM/MPO	-9.5	2.4	-9.6	4.4
10Gbit/s Ethernet LAN PHY (10.3125 Gbit/s)	WL3 OCLD / 2x40G+2x10G OCI	SFP+/10G/1310L/SM/LC	-10.3	.5	-8	1
		SFP+/10G/850I/MM/LC	-11.9	0	-9.3	1
	WL3n MOTR	SFP+/10G/1310L/SM/LC	-10.3	.5	-8	1
		SFP+/10G/850S/MM/LC	-11.9	0	-9.3	1
		XFP/10G/1310S/SM/LC	-13	0.5	-8	1

Client Service	Card Type	Client Port Options Pluggable type / maximum speed / wavelength /Single-Mode(SM) or Multimode (MM) / connector type	Rx Min (dBm)	Rx Max (dBm)	Tx Min (dBm)	Tx Max (dBm)
	4x10G OTR XFP	XFP/10G/850S/MM/LC	-11.9	0	-9.3	1
	2x10G OTR	XFP/10G/1310S/SM/LC	-13	0.5	-8	1
		XFP/10G/850S/MM/LC	-11.9	0	-9.3	1
10Gbit/s Ethernet WAN PHY (9.9532 Gbit/s)	WLAi FOTR	SFP+/10G/1310/SM/LC	-13	0.5	-8.0	1.0
		SFP+/10G/850/SM/LC	-12.4	0	-10.2	2.0
	WL3n MOTR	SFP+/10G/1310L/SM/LC	-10.3	0.5	-8.0	1.0
	4x10G OTR SFP/SFP+	SFP+/10G/1310L/SM/LC	-10.3	0.5	-8.0	1.0
	2x10G OTR	XFP/10G/1310S/SM/LC	-13.0	0.5	-8.0	1.0
Gigabit Ethernet (1.25GBit/s)	2.7G MOTR [1]	SFP/2.7G/1310I/SM/LC	-23	-3	-12.5	0
		SFP/1.25G/850S/MM/LC				
	10G MOTR	SFP/2.7G/1310I/SM/LC	-23	-3	-12.5	0
		SFP/1.25G/850S/MM/LC	-11.5	-0.5	-19.5	0
Fibre Channel FC32G (28.05G)	WLAi FOTR	SFP28/32GFC/1310/SM/LC	-15.2	2.0	-7.0	4.0
		SFP28/16GFC/850/SM/LC	-14	2.0	-8.2	4.0
Fibre Channel/FICON FC16G (14.025G)	WLAi FOTR	SFP28/32GFC/1310/SM/LC	-15.2	2.0	-7.0	4.0
		SFP28/16GFC/850/SM/LC	-14	2.0	-8.2	4.0
Fibre Channel 10Gbit/s FC1200 (10.5187Gbit/s)	WL3n MOTR	SFP+/10G/1310L/SM/LC	-10.3	0.5	-8.0	1.0
		SFP+/10G/850I/MM/LC	-11.9	0	-9.3	1.0
	4x10G OTR XFP	XFP/10G/1310S/SM/LC	-13	0.5	-8	1.0
		XFP/10G/850S/MM/LC	-11.9	0	-9.3	1.0
	2x10G OTR	XFP/10G/1310S/SM/LC	-13	0.5	-8	1.0
		XFP/10G/850S/MM/LC	-11.9	0	-9.3	1.0
Fibre Channel 8Gbit/s FC800 (8.5Gbit/s)	4x10G OTR SFP/SFP+	SFP+/10G/1310L/SM/LC	-21	1.5	-8.4	0.5
		SFP+/10G/850I/MM/LC	-16.5	1.0	-8.0	0
	2x10G OTR	XFP/10G/1310S/SM/LC	-13	0.5	-8	1
		XFP/10G/850S/MM/LC	-11.9	0	-9.3	1
Fibre Channel/FICON 4Gbit/s FC400 (4.25Gbit/s)	4x10G OTR SFP/SFP+	SFP+/10G/1310L/SM/LC	-21	1.5	-8.4	0.5
		SFP+/10G/850I/MM/LC	-16.5	1.0	8.0	0
	10G MOTR	SFP/2.7G/1310L/SM/LC	-19.3	-3	-11.5	-1.0
		SFP/2.7G/850I/MM/LC	-16	0	-11	-0.5
Fibre Channel/FICON 2Gbit/s	10G MOTR	SFP/2.7G/1310I/SM/LC	-23	-3	-12.5	0
		SFP/1.25G/850S/MM/LC	-11.5	-0.5	-19.5	0
	2.7G MOTR [1]	SFP/2.7G/1310I/SM/LC	-23	-3	-12.5	0

Client Service	Card Type	Client Port Options Pluggable type / maximum speed / wavelength /Single-Mode(SM) or Multimode (MM) / connector type	Rx Min (dBm)	Rx Max (dBm)	Tx Min (dBm)	Tx Max (dBm)
FC200 (2.125 Gbit/s)		SFP/1.25G/850S/MM/LC	-11.5	-0.5	-19.5	0
Fibre Channel/FICON 1Gbit/s FC100 (1.062 Gbit/s)	10G MOTR	SFP/2.7G/1310I/SM/LC	-23	-3	-12.5	0
		SFP/1.25G/850S/MM/LC	-11.5	-0.5	-19.5	0
	2.7G MOTR[1]	SFP/2.7G/1310I/SM/LC	-23	-3	-12.5	0
		SFP/1.25G/850S/MM/LC	-11.5	-0.5	-19.5	0
STM-64 (9.9532 Gbit/s)	WLAi FOTR	SFP+/10G/1310/ LC	-13.0	0.5	-8.0	1.0
	WL3n MOTR	SFP+/10G/1310I/SM/LC	-10.3	0.5	-8.0	1.0
	4x10G OTR XFP	XFP/10G/1310S/SM/LC	-13.0	0.5	-8.0	1.0
	2x10G OTR	XFP/10G/1310S/SM/LC	-13.0	0.5	-8.0	1.0
STM-16 (2.488 Gbit/s)	10G MOTR	SFP/2.7G/1310I/SM/LC	-23.0	-3.0	-12.5	0
	2.7G MOTR	SFP/2.7G/1310I/SM/LC	-23.0	-3.0	-12.5	0
STM-4 (622 Mbit/s)	10G MOTR	SFP/2.7G/1310I/SM/LC	-23.0	-3.0	-12.5	0
	2.7G MOTR[1]	SFP/2.7G/1310I/SM/LC	-23.0	-3.0	-12.5	0
STM-1 (155 Mbit/s)	10G MOTR	SFP/2.7G/1310I/SM/LC	-23.0	-3.0	-12.5	0
	2.7G MOTR[1]	SFP/2.7G/1310I/SM/LC	-23.0	-3.0	-12.5	0
IBM PSIFB (5Gbit/s)	4x10G OTR SFP/SFP+	SFP+/10G/1310L/SM/LC	-21	1.5	-8.4	0.5
	2x10G OTR	XFP/10G/1310S/SM/LC	-13.0	0.5	-8.0	1.0
IBM ISC-3 Peer Mode 2G (2.125GBit/s)	4x10G OTR SFP/SFP+	SFP+/10G/1310L/SM/LC	-21	1.5	-8.4	0.5
	10G MOTR	SFP/2.7G/1310I/SM/LC	-23.0	-3.0	-12.5	0
	2.7G MOTR[1]	SFP/2.7G/1310I/SM/LC	-23.0	-3.0	-12.5	0
IBM ISC-3 Peer Mode 1G (1.0625Gbit/s)	10G MOTR	SFP/2.7G/1310I/SM/LC	-23.0	-3.0	-12.5	0
	2.7G MOTR[1]	SFP/2.7G/1310I/SM/LC	-23.0	-3.0	-12.5	0
DVB-ASI (270Mbit/s)	10G MOTR	SFP/2.7G/1310I/SM/LC	-23.0	-3.0	-12.5	0
	2.7G MOTR[1]	SFP/2.7G/1310I/SM/LC	-23.0	-3.0	-12.5	0

Table 11: Client Power Parameters

5.10 OTU Interface options

The table below provides details of the OTU client interface options for both the receive and transmit interfaces of the client facing optical interfaces. Aggregation of client signals into OTU payloads is only permissible at OTU1. Aggregation of more than one client signal into OTU2, or OTU4 is not available.

Client ports	Wavelength
Non OTU client one end to OTU1 client other end	OTU1 (known as 2.7G wavelength)
Non OTU client one end to OTU1 client other end	OTU2 (known as 10G wavelength)

Non OTU client one end to OTU2 client other end (Note:- Non OTU client options can only be STM-64 or 10GEWAN PHY)	OTU2 (known as 10G wavelength)
OTU1 client one end to OTU1 client other end	OTU1 (known as 2.5G wavelength)
OTU1 client one end to OTU1 client other end	OTU2 (known as 10G wavelength)
OTU2 client one end to OTU2 client other end	OTU2 (known as 10G wavelength)
OTU3 Client one end to OTU3 Client other end	OTU4 (known as 100G wavelength)
Non OTU client one end to OTU4 client other end	OTU4 (known as 100G wavelength)
OTU4 client one end to OTU4 client other end	OTU4 (known as 100G wavelength)

Table 12: OTU interface Options

Note that 10G client interfaces will map into two types of OTU2 in the transport layer.

- STM64, 10GE WAN PHY and lower bit rates (e.g. 8G Fibre Channel) map into OTU2
- 10GE LAN PHY and 10G Fibre Channel map into an OTU2e

The OTU2e is an extended rate OTU2 enabling it to transport the larger payloads of certain signals.

6. Managed Services supported

The managed services are available with the following interfaces:

- Gigabit Ethernet, 10 Gigabit Ethernet (LAN Phy), 10 Gigabit Ethernet (WAN Phy), 40 Gigabit Ethernet, 100 Gigabit Ethernet, 400 Gigabit Ethernet
- SDH STM-1, STM-4, STM-16, STM-64,
- 1G Fibre Channel, 2G Fibre Channel, 4G Fibre Channel, 8G Fibre Channel, 10G Fibre Channel, 16G Fibre Channel, 32G Fibre Channel
- FICON, 2G FICON, 4G FICON, 16G FICON
- IBM ISC-3 Peer Mode1G, IBM ISC-3 Peer Mode 2G, IBM ISC-3 STP
- DVB-ASI
- 5G IBM PSIFB
- OTU1, OTU1e, OTU2, OTU3, OTU2e, OTU4

OSEA 6500 services are intended for connection to standard optical interfaces of 850 nm multimode or 1310 nm and 1550 nm single-mode types. No electrical interfaces are offered. Table 13 gives details of the optical interface/service options. These interfaces are described in the documents listed against each interface in the “References” section.

OSEA 6500 Client Interfaces				
Service Supported	**Bandwidth (bit/s)**	**850nm (MM)**	**1310nm (MM)**	**1310nm (SM)**
1G Ethernet	1.25G	Yes	No	Yes

10G Ethernet (LAN PHY)	10.3125G	Yes	No	Yes
10G Ethernet (WAN PHY)	9.95328G	Yes	No	Yes
40G Ethernet	41.25G	No	No	Yes
100G Ethernet	103.125G	Yes	No	Yes
400G Ethernet	412.5G	No	Yes	Yes
SDH STM-1	155M	No	No	Yes
SDH STM-4	622M	No	No	Yes
SDH STM-16	2.4G	No	No	Yes
SDH STM-64	9.95328G	No	No	Yes
1G Fibre Channel	1.06G	Yes	No	Yes
2G Fibre Channel	2.125G	Yes	No	Yes
4G Fibre Channel	4.24G	Yes	No	Yes
8G Fibre Channel	8.5G	Yes	No	Yes
10G Fibre Channel	10.5187G	Yes	No	Yes
16G Fibre Channel	14.025G	Yes	No	Yes
32G Fibre Channel	28.05G	Yes	No	Yes
FICON	1.06G	Yes	No	Yes
FICON Express 2G	2.125G	Yes	No	Yes
FICON Express 4G	4.24G	Yes	No	Yes
FICON 16G	14.025G	Yes	No	Yes
IBM ISC-3 Peer Mode 1G	1.06G	Yes	No	Yes
IBM ISC-3 Peer Mode 2G	2.125G	Yes	No	Yes
IBM ISC-3 STP	2.125G	Yes	No	Yes
DVB-ASI	270M	Yes	No	Yes
5G IBM PSIFB	5G	No	No	Yes
OTU1	2.7G	No	No	Yes
OTU2	10.709G	No	No	Yes
OTU2e	11.09G	No	No	Yes
OTU3	43.018G	No	No	Yes
OTU4	111.8G	No	No	Yes

Table 13: Interface options

FICON is a proprietary storage area protocol from IBM, and is used in many SAN customer sites. A coupling link is required if the customer is running sysplex timing on their Storage Area Network, as a special timing signal is broadcast over the network to ensure data integrity. For OSEA 6500, the customer uses the IBM-ISC3 (STP) protocol via an optical interface and connect to their server; this would then be transported across the OSEA 6500 bearer exiting the network in the same way.

7. Circuit protection

Three levels of fibre/circuit protection are available:

- Optical Spectrum Extended Access Standard
- Optical Spectrum Extended Access Resilience Option 1

- Optical Spectrum Extended Access Resilience Option 2

Wavelength switching protection is only available on RO1 bearers. Wavelength switching protection enables protected wavelengths to be automatically switched to an alternative optical path to maintain service between the same wavelength A and B ends. Wavelength switching to an alternative site is not offered. The incoming line signals are monitored and failure of this will trigger the system to switch the wavelength. This is typically done within 50ms of a failure being detected however some configurations may take slightly longer. User's equipment is not monitored.

Protocols with latency sensitivities (e.g. Fibre Channel, ESCON, FICON) may require customer reconfiguration following an incident resulting in a switch to the protection path. The Openreach equipment will continue to function on the protection path.

Refer to the OSEA 6500 product description for further information on bearer resilience options and wavelength protection http://www.openreach.co.uk/orpg/products/oss/oss.do.

8. Geographical Availability

The Openreach OSEA 6500, including Filter Connect, service is offered throughout the United Kingdom subject to survey.

9. Buffer crediting

OSEA 6500 and OSEA 6500 Filter Connect equipment does not support buffer crediting but is transparent to customer own equipment distance extension protocols.

10. Connector

10.1 Managed wavelengths

For installations other than the OSEA 6500 Filter Connect 2U base-build, an Openreach provided patch panel interface is the Network Termination Point (NTP), i.e. the point of connection between the Openreach Network Terminating Equipment (NTE) and the CPE interface for managed wavelengths. The NTP on the OSEA 6500 Filter Connect 2U base-build is the optical client interface on the installed wavelength card. Optical interfaces are presented as LC connectors only.

For 100Gbit/s SR4 and-40Gbit/s SR4 850nm and 400Gbit/s DR4 1310nm client interfaces on managed wavelengths, MPO [9] compliant connectors on multi-fibre cables will need to be installed and will require direct connection between the Openreach NTE & the CPE. Openreach, via their partners, will provide a 25 metre MPO compliant connector terminated multi-fibre cable and will be responsible for the connection to the OSEA 6500 interface. The remaining cable will be coiled at the bottom of the cabinet in preparation for the customer to connect to their own equipment.

10.2 Filter Connect wavelengths

The customer interface and service demarcation point for CP provided alien wavelengths on OSEA Filter Connect is on the optical filter ports. These are dual LC. Either a single duplex or a pair of simplex LC cables may be used where appropriate, though duplex cables with dual LC connectors will ensure that transmit and receive connections are correctly made the right way round

11. Fibre

Where a service employing a local or remote single-mode interface is provided, all fibre optic connections to and from the patch panel use single-mode fibre 9/125 micron according to ITU-T G.652[2].

Where a service employing a multimode interface is provided all fibre optic connections to and from the patch panel use multimode fibre 62.5/125 micron or 50/125 micron @ 850nm according to ITU-T G.651[1].

12. Transmission

The NTE is capable of transporting data at up to 800Gbit/s per wavelength. Multiplexing is carried out by passive filter components that combine the light of different optical channels using different wavelengths on to a single fibre pair. De-multiplexing is carried out by passive filter components that break out the aggregate signal from a single fibre pair into optical channels.

13. “Friendly” Alien Wavelengths

A “Friendly” Alien wavelength has a transponder at one end and a coloured light hand-off via a filter at the other end. They can be used by a CP to connect from a remote site to their own network without converting back to an electrical signal.

Only 100G coherent “Friendly” Alien managed wavelengths are supported by OSEA 6500 and OSEA 6500 Filter Connect.

This solution is predicated on the CPs network being based on a Ciena ROADM & DOC (Domain Optical Controller) controlled 6500 platform.

Openreach will not permit “Friendly” Alien wavelength services to be interconnected to non-Ciena 6500 DOC controlled ROADM networks.

The CP/customer is responsible for providing the channel plan and other optical/provisioning characteristics for “Friendly” Alien wavelengths. Available wavelengths, based on 50GHz and 100GHz spacing Ciena 6500 channel plans, are shown in the following table:

Channel ID	Wavelength (nm)	Frequency (THz)	OSEA 6500 50Ghz Wavelength Plan	OSEA 6500 100Ghz Wavelength Plan	Channel ID	Wavelength (nm)	Frequency (THz)	OSEA 6500 50Ghz Wavelength Plan	OSEA 6500 100Ghz Wavelength Plan
1	1530.33	195.9	Y	Y	45	1547.72	193.7	Y	Y
2	1530.72	195.85	Y		46	1548.11	193.65	Y	
3	1531.12	195.8	Y	Y	47	1548.51	193.6	Y	Y
4	1531.51	195.75	Y		48	1548.91	193.55	Y	
5	1531.9	195.7	Y	Y	49	1549.32	193.5	Y	Y
6	1532.29	195.65	Y		50	1549.72	193.45	Y	
7	1532.68	195.6	Y	Y	51	1550.12	193.4	Y	Y
8	1533.07	195.55	Y		52	1550.52	193.35	Y	
9	1533.47	195.5	Y	Y	53	1550.92	193.3	Y	Y
10	1533.86	195.45	Y		54	1551.32	193.25	Y	
11	1534.25	195.4	Y	Y	55	1551.72	193.2	Y	Y
12	1534.64	195.35	Y		56	1552.12	193.15	Y	
13	1535.04	195.3	Y	Y	57	1552.52	193.1	Y	Y
14	1535.43	195.25	Y		58	1552.93	193.05	Y	
15	1535.82	195.2	Y	Y	59	1553.33	193	Y	Y
16	1536.22	195.15	Y		60	1553.73	192.95	Y	
17	1536.61	195.1	Y	Y	61	1554.13	192.9	Y	Y
18	1537	195.05	Y		62	1554.54	192.85	Y	
19	1537.4	195	Y	Y	63	1554.94	192.8	Y	Y
20	1537.79	194.95	Y		64	1555.34	192.75	Y	
21	1538.19	194.9	Y	Y	65	1555.75	192.7	Y	Y
22	1538.58	194.85	Y		66	1556.15	192.65	Y	
23	1538.98	194.8	Y	Y	67	1556.55	192.6	Y	Y
24	1539.37	194.75	Y		68	1556.96	192.55	Y	

Channel ID	Wavelength (nm)	Frequency (THz)	OSEA 6500 50Ghz Wavelength Plan	OSEA 6500 100Ghz Wavelength Plan	Channel ID	Wavelength (nm)	Frequency (THz)	OSEA 6500 50Ghz Wavelength Plan	OSEA 6500 100Ghz Wavelength Plan
25	1539.77	194.7	Y	Y	69	1557.36	192.5	Y	Y
26	1540.16	194.65	Y		70	1557.77	192.45	Y	
27	1540.56	194.6	Y	Y	71	1558.17	192.4	Y	Y
28	1540.95	194.55	Y		72	1558.58	192.35	Y	
29	1541.35	194.5	Y	Y	73	1558.98	192.3	Y	Y
30	1541.75	194.45	Y		74	1559.39	192.25	Y	
31	1542.14	194.4	Y	Y	75	1559.79	192.2	Y	Y
32	1542.54	194.35	Y		76	1560.2	192.15	Y	
33	1542.94	194.3	Y	Y	77	1560.61	192.1	Y	Y
34	1543.33	194.25	Y		78	1561.01	192.05	Y	
35	1543.73	194.2	Y	Y	79	1561.42	192	Y	Y
36	1544.13	194.15	Y		80	1561.83	191.95	Y	
37	1544.53	194.1	Y	Y	81	1562.23	191.9	Y	Y
38	1544.92	194.05	Y		82	1562.64	191.85	Y	
39	1545.32	194	Y	Y	83	1563.05	191.8	Y	Y
40	1545.72	193.95	Y		84	1563.45	191.75	Y	
41	1546.12	193.9	Y	Y	85	1563.86	191.7	Y	Y
42	1546.52	193.85	Y		86	1564.27	191.65	Y	
43	1546.92	193.8	Y	Y	87	1564.68	191.6	Y	Y
44	1547.32	193.75	Y		88	1565.09	191.55	Y	

Table 14: “Friendly Alien" wavelength plan

14. ROADM

OSEA 6500 provides the capability to remotely switch traffic by utilising ROADM (Reconfigurable Optical Add Drop Multiplexer) Wavelength Selective Switch (WSS) modules. It allows individual or multiple wavelengths (carrying data) to be added and/or dropped from a transport fibre without the need to convert the signals on all of the WDM channels to electronic signals and back again to optical signals.

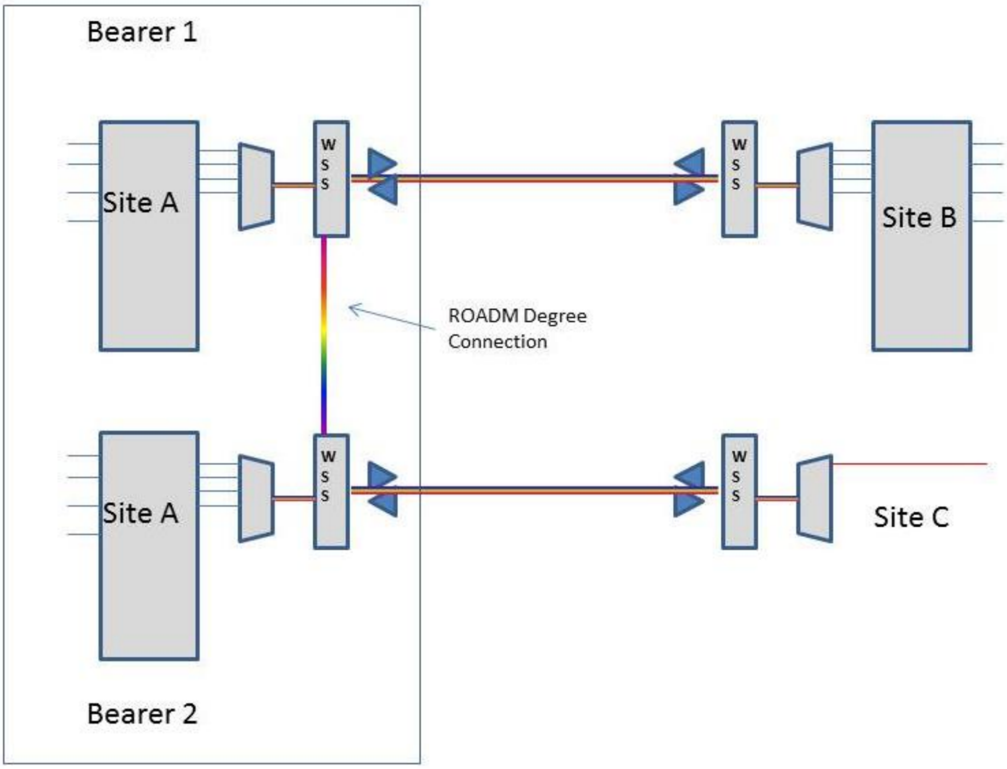

Figure 2: Example ROADM configuration

15. NTE specifics

By default OSEA 6500 and OSEA 6500 Filter Connect chassis are installed into a customer's cabinet(s).

The 2-Slot, 7-Slot & 14-Slot shelves may use either ETSI or 19" rack mounting practice. The 32-Slot shelf can only use ETSI rack mounting practice. Where there is a choice, it is the responsibility of the CP to inform Openreach of the mounting practice to be used

The rack should be grounded with a clean earth supply.

On request from CP, Openreach can provide suitable cabinet(s) at an additional charge.

BT cabinet is 600mm x 600mm footprint with a height of 2.2 meters.

There are four chassis types available in either AC or DC power, these are detailed in table 15. For all chassis types and power options Openreach requires the following additional power supplies:

A 240V AC supply using a 13A switched socket to power the remote network management system. The socket must be within 1.5m of that equipment.

A 240V AC power supply to power Openreach test equipment during both initial commissioning and subsequent maintenance support activities. This socket must be within 1.5m of the NTE.

Further information on installation and power requirements is available from the OSEA Product description.

Chassis type	Height	AC power	DC power
2 Slot	2U	Yes	Yes
7 Slot	6U	Yes	Yes

14 Slot	13U	Yes via a rectifier (additional 2U)	Yes
32 Slot	22U	Yes via 2 x rectifiers (additional 4U)	Yes
Advanced Amplifier and Filter Chassis Small (6ch or 10ch)	1U	Yes	Yes
Advanced Amplifier and Filter Chassis Large (48ch)	2U	Yes	Yes

Table 15: Chassis options

Further information on specific power requirements can be found in the Openreach AC/DC planning guide which can be found here: www.openreach.co.uk

16. Further Information

For enquiries concerning connection availability between particular sites and for further product information about this service please visit the website at www.openreach.co.uk or contact your Openreach Sales & Relationship Manager or sales specialist.

If you have enquiries relating to this document then please contact: orsinsfa@openreach.co.uk

17. References

1	ITU-T G.651	Recommendation G.651 (02/98) - Characteristics of a 50/125 µm multimode graded index optical fibre cable
2	ITU-T G.652	Recommendation G.652 (04/97) - Characteristics of a single-mode optical fibre cable
3	ESCON	IBM Proprietary as specified in IBM Red Book Standard for GDPS.
4	Fast Ethernet	IEEE 802.3
5	Fibre Channel	ANSI/NCITS X3.288-1996
6	FICON	FICON, the IBM zSeries zOS channel protocol succeeding ESCON
7	Gigabit Ethernet	IEE 802.3z or SIN 360 Gigabit Ethernet for the BT Network
8	ITU-T G.957	Optical interfaces for equipment and systems relating to the synchronous digital hierarchy
9	IEC 61754-7	Standard for "Fibre Optic Interconnecting Devices & Passive Components – Fibre Optic Connector Interfaces – Part 7: Type MPO Connector Family"
10	ETSI	European Telecommunications Standards Institute

18. Abbreviations

CP	Communications Provider
CPE	Customer Premises Equipment
DCMs	Dispersion Compensation Modules
DOC	Domain Optical Controller
DWDM	Dense Wavelength Division Multiplexing
DVB	Digital Video Broadcasting
ELS	Edge-Line System (Advanced Amplifier and Filter Chassis)
ESCON	Enterprise Systems Connectivity architecture
ESRM	Enterprise Storage Resource Management
FC	Fibre Channel
FICON	Fibre Connectivity
Gbit/s	Gigabits per second
IBM	International Business Machines
IEC	International Electrotechnical Commission
ITU-T	International Telecommunication Union- Telecommunications standardization Sector
km	Kilometre
LC	Lucent Connector
LAN	Local Area Network
MM	MultiMode
MPO	Multi-fibre Push On
NTE	Network Terminating Equipment
NTP	Network Terminating Point
OSEA	Optical Spectrum Extended Access
OTU	Optical Transport Unit
PHY	Physical Layer
ROADM	Reconfigurable Optical Add Drop Multiplexer
Rx	Receive
SAN	Storage Area Network

SC	Subscription Channel
SDH	Synchronous Digital Hierarchy
SIN	Supplier Information Note
SM	Single Mode
SRM	Storage Resource Management
STM	Synchronous Transport Module
Tx	Transmit
WDM	Wavelength Division Multiplexing
WSS	Wavelength Selective Switch

19. History

Issue	Date	Changes
Issue 1	February 2014	First Issue
Issue 1.1	April 2014	Table 1 and Table 5 updated Change SINet site references from http://www.sinet.bt.com to http://www.btplc.com/sinet/
Issue 1.2	January 2016	Updated link on page 11, section 3- NTE specifics under Table 5
Issue 1.3	March 2016	Amendments to client interface tables and removal of 40G coherent friendly alien Wavelength options.
1.4	August 2016	Addition of note in section 1 to state that the Ciena 6500 2 slot MOTR bearers & expansion chassis products are no longer available for new supply as from 11 May 2016.
1.5	September 2017	Correction of 40G Ethernet 850nm entry from Yes to No Section 2.7, removal of 40G text Section 2.11, removal of OTU3 text Table 4 correcting of Channel 44 frequency and wavelength values Section 3, update of mounting practice text
1.6	April 2018	Removal of ESCON, SRM250G, ESRM250G as supported services. Section 2.1; correction of distance for mid-point amplification from 100km to 113km
1.7	October 2018	Addition of OSEA 6500 Filter Connect information. Reformatting of document.
1.8	September 2020	Changes to branding, from BT to Openreach including changes to reflect new Openreach SIN site and Openreach SIN email address
1.9	January 2021	Update to include OSEA 6500 MUX 100 and OSEA 6500 FLEX 100 (Wavelogic AI) information. Update to "Table 1: ITU Wavelength Grid" to correct the wavelength value for frequency 193.75THz. Update to section 10.1 to remove 'SC' connector option.
2.0	May 2021	Correction to Table 1: ITU Wavelength Grid with OSEA6500 Filters. The four channels between frequencies 194.1 and 193.4 corrected to C4H and C4L from B4H and B4L respectively.
2.1	May 2022	Update to note that the CMD96 filter is not available for new supply after 2 May 2022.
2.2	December 2022	Update to note that the 2.7G MOTR wavelength card is not available for new supply after 22 January 2023
2.3	November 2023	Update to document to include OSEA 6500 MUX 800 (WaveLogic 5E) information. Plus addition of CMD 42 filter and Advanced Amplifier and Filter Chassis.
2.4	October 2024	Addition of OSEA Ring and Chain and OSEA Link Bearer.

< END >